FINAL REPORT

Zero VOC, Coal Tar Free Splash Zone Coating (SZC)

ESTCP Project WP-200528

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14. ABSTRACT
The “Splash Zone” is defined as the area between the year’s lowest tidal mark and up to ten feet above the year’s highest tidal mark. Early SBIR funded studies of the SBIR developed polysulfide modified novolac epoxy formulation (renamed Zero VOC, Coal Tar Free Splash Zone Coating (SZC)) indicated that the SZC will provide at least “twice” the performance compared to the currently specified coating systems. This demonstration provides a full scale validation of the SZC for use as an in-service waterfront maintenance system and enables the transition of this coal tar free coating directly into the hands of DOD end users who require waterfront metal (e.g., sea walls, sheet pile) maintenance painting. This project addresses performance and environmental requirements for sustainment and reduction of VOC and HAP emissions due to the SZC being free of toxic metals, hazardous air pollutant free, contains no coal tar pitch, and has zero VOC’s.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AIM	Architectural and Industrial Maintenance Coatings
AQMD	Air Quality Management District
ASTM	American Society for Testing and Materials
CBA	Cost Benefit Analysis
CCB	Construction Criteria Base
CCS	Coating Condition Survey
C/SF	Cost per Square Foot
CPUA	Cost Per Unit Area
COTS	Commercial Off The Shelf
CNO	Chief of Naval Operations
DFT	Dry Film Thickness
DOD	Department of Defense
DPS	Detailed Performance Standard
ECAM	Environmental Cost Analysis Methodology
EICO	Engineering Innovation and Criteria Office
EPA	Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
HAP	Hazardous Air Pollutant
HAZMAT	Hazardous Material
HVLP	High Volume, Low Pressure
IMC	Industrial Maintenance Coating(s)
IRR	Internal Rate of Return
LP	Liquid Polysulfide
MIBK	Methyl Isobutyl Ketone
MPI	Master Painter's Institute
NACE	National Association of Corrosion Engineers
NAS	Naval Air Station
NAVSTA	Naval Station
NAVFAC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
NESHAP	National Emission Standards for Hazardous Air Pollutants
NTPEP	National Transportation Product Evaluation Program
NPV	Net Present Value
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
P2	Pollution Prevention
PCS	Plural Component Spray

POC	Point of Contact
PS	Paint System
QA/QC	Quality Assurance / Quality Control
ROI	Return on Investment
SARA	
SBIR	Small Business Innovative Research
SCAQMD	South Coast Air Quality Management District
SF	Square Foot
SSP	Steel Sheet Pile
SSPC	The Society for Protective Coatings
SZC	Splash Zone Coating
TCLP	Toxic Characteristic Leaching Procedure
TOC	Total Ownership Cost
TRI	Toxic Release Inventory
VOC	Volatile Organic Compound
UFGS	Unified Facilities Guide Specification
UHPWJS	Ultra High Pressure Water Jetting System
UV	Ultra Violet

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Initial developmental funding was provided by the SBIR program. This demonstration project was co-funded by ESTCP (Environmental Security Technology Certification Program) and the OSD CPC (Office of Secretary of Defense Corrosion Prevention and Control) programs.

EXECUTIVE SUMMARY

The "Splash Zone" is defined as the area between the year's lowest tidal mark and up to ten feet above the year's highest tidal mark. It is extremely difficult to protect steel structures against corrosion in this zone where corrosion rates have been documented to exceed 30 mils per year on unprotected steel. This is more than 6 times the corrosion rate typically found for steel under constant water immersion.

Specific guidance for coating Navy's steel sheet piling employs two coating system options for the initial painting of steel placed in sea water immersion/splash zones: 1) three coats of epoxy-polyamide and 2) two coats of coal tar pitch epoxy-polyamide. In theory, the three coat epoxy system should provide better in place service than the two coat coal tar epoxy system. In practice, the coal tar system is use almost exclusively due to the lower material cost. The coal tar system provides approximately five years splash zone service before maintenance is required which can include complete removal and reapplication. However, maintenance is rarely done due to the high cost and environmental issues that need to be addressed.

The environmental issues with the two coating system options include high VOC content, Hazardous Air Pollutants (HAP's) and may also include hazardous pigment content. The coal tar epoxy also contains Coal Tar Pitch which is regulated by OSHA due to known human carcinogen content.

The first liquid polysulfide polymer became commercially available in 1943. Today, there are several liquid polysulfide polymers, each with distinctly different properties, but similar in chemical structure. The liquid polysulfides have the advantage of being room temperature vulcanized, meaning they can be cured at ambient temperatures after the addition of an oxygen donating curing agent.

Epoxy resins date back to about 1949. Their many excellent properties include rapid curing at normal temperatures, good adhesion to most surfaces, toughness, and chemical resistance. Today, versatile epoxy resin compounds and systems are customized to meet the different physical properties required by various markets. None of the commercially tested coatings met the desired Navy performance requirements. The two most significant limitations were the inability of the commercial coatings to adequately bond to clean, semi-damp steel and had insufficient curing under immersion. To make a flexible epoxy that could potentially meet the requirements of the SZC, a liquid polysulfide polymer was used. The polysulfide addition improves certain physical properties without adversely affecting the existing performance capabilities of the epoxy resin.

Facilities Engineering Command's (NAVFAC) Small Business Innovative Research (SBIR) program solicited the topic entitled "Polysulfide Modified Epoxy Novolac Cladding for Steel Immersion/Splash Zone Service." NFESC subsequently awarded Phase I and Phase II work to PolySpec Corporation and Polymeright, Inc. Phase I results were promising whereas preliminary

Phase II results were exceptional. The tests included small scale application trials under actual field conditions.

Early SBIR funded studies of the SBIR-developed polysulfide modified novolac epoxy formulation (renamed Zero VOC, Coal Tar Free Splash Zone Coating (SZC)) indicated that the SZC will provide at least “twice” the performance compared to the currently specified coating systems. This demonstration provides a full scale validation of the SZC for use as an in-service waterfront maintenance system and enables the transition of this coal tar free coating directly into the hands of DOD end users who require waterfront metal (e.g., sea walls, sheet pile) maintenance painting.

This project addresses Air Force, Army, and Navy performance and environmental requirements for sustainment and reduction of VOC and HAP emissions. Federal, state and local environmental agencies such as the EPA and Air Quality Management District’s (AQMD’s) across the country classify many VOC’s as hazardous and restrict their emissions through regulations such as the Clean Air Act and local EPA and AQMD rules. Chief of Naval Operations (CNO) directives require significant reductions in the amount of hazardous waste generated by the Navy. This technology will satisfy all of these requirements due to the SZC being free of toxic metals, hazardous air pollutant free, contains no coal tar pitch, and has zero VOC’s.

1. INTRODUCTION

1.1 Background

The "Splash Zone" is defined as the area between the year's lowest tidal mark and up to ten feet above the year's highest tidal mark. It is extremely difficult to protect steel structures against corrosion in this zone where corrosion rates have been documented to exceed 30 mils per year on unprotected steel. This is more than 6 times the corrosion rate typically found for steel placed in water below the intertidal zone. The Navy owns about 650,000 linear feet (LF) of waterfront bulkheads, quay walls, and seawalls with a plant replacement value (PRV) of about $1.24B. About 30% of these waterfront structures are composed of steel sheet piling (SSP). The annual cost for maintaining these SSP structures is approximately $20M.

Unified Facilities Guide Specification (UFGS) - 09967 "Coating of Steel Waterfront Structures" is used to specify coating of the Navy's steel sheet piling. It employs two coating system options for use in the initial painting of steel placed in sea water immersion/splash zones:

- three coats epoxy-polyamide [Society for Protective Coatings (SSPC) Paint System (PS) 13.01], or
- two coats coal tar pitch epoxy-polyamide (SSPC PS 11.01).

In theory, the three coat epoxy system should provide better in place service than the two coat coal tar epoxy system. Historically and in practice, the coal tar system is almost exclusively used due to the lower material cost. Nonetheless, the coal tar system provides approximately five years splash zone service before complete removal and reapplication would be required to prevent the more aggressive corrosion of the exposed substrate. Despite the need for recoating or planned maintenance it is rarely done due to the high cost and environmental issues that need to be addressed.

Each coat of coating system SSPC PS 13.01 contains 300 g/L of Volatile Organic Compounds (VOC's), Hazardous Air Pollutants (HAP's) of Methyl Isobutyl Ketone (MIBK) and Xylene, and the pigment Chromium Oxide. Each coat of SSPC PS 11.01 contains 30 % by weight Coal Tar Pitch (regulated by OSHA: known human carcinogen, National Toxicology Program), 192 g/l of VOC's, and Xylene (HAP).

In effect since August 2002, California's South Coast Air Quality Management District (SCAQMD), Rule 1113 "Architectural Coatings," requires all Industrial Maintenance Coatings (IMC), including SZCs, to contain no more than 100 g/l of VOC's effective August 2006.[1,2] The initial shop application of UFGS 09 97 13.26 to a typical 1,000'(L) x 20'(H) (20,000 SF) sheet pile bulkhead releases 597 pounds of VOC's, contains 847 pounds of coal tar pitch, and is not suitable for in-service maintenance painting.

In 2001, the Naval Facilities Engineering Service Center (NFESC) assessed commercially available coatings for use in splash zone maintenance, including shop application under simulated marine condition. It was determined that the currently available coatings did not perform any better than the coating systems being used. As a result, in FY 02, the Naval

Facilities Engineering Command's (NAVFAC) Small Business Innovative Research (SBIR) program solicited the topic entitled "Polysulfide Modified Epoxy Novolac Cladding for Steel Immersion/Splash Zone Service." NFESC subsequently awarded Phase I and Phase II work to PolySpec Corporation and Polymeright, Inc. Phase I results were promising whereas preliminary Phase II results were exceptional. The tests included small scale application trials under actual field conditions. These studies indicated that the SBIR-developed formulations, renamed as the Zero VOC, Coal Tar Free Splash Zone Coating (SZC), will provide at least "twice" the performance compared to the currently specified coating systems. The estimated performance is based on comparative laboratory and small scale testing.

1.2 Objectives of the Demonstration

This demonstration provides a full scale validation of the SZC for use as an in-service waterfront maintenance system and enables the transition of this coal tar free coating directly into the hands of DOD end users who require waterfront metal (e.g., sea walls, sheet pile) maintenance painting.

Demonstration results are in the process of transitioning into commercial guidance such as a new Master Painters Institute (MPI) Detailed Performance Standard (DPS) for the SZC. Results will be amending the coating systems employed by Unified Facilities Guide Specification (UFGS)-09967 "Coating of Steel Waterfront Structures." The DPS and the amended UFGS will be web-displayed at http://www.paintinfo.com and http://www.wbdg.org/ccb/browse_org.php?o=70 respectively, for direct use by Tri-service activities with splash zone steel in need of either new or maintenance painting. In addition, results will be posted at the Joint Service P2 Library and presented at the Tri-service Environmental Centers' Coordinating Committee meeting, if applicable. Intended technology users are Navy, Army, Air Force, Marines, Bureau of Reclamation, and private industry.

1.3 Regulatory Drivers

The project addresses the following requirements:

- Army Task N.312/N.000-08: Sustainable Painting Operations for the Total Army
- Air Force Need 200-204: Reduce VOC Emissions from Paint Application Systems
- Air Force Need 200-240: Methods to Reduce VOC Emissions/Hazardous Waste from Paint
- Navy 2.1.01.g: Control/Reduce Emissions from Coating, Stripping and Cleaning Operations
- Navy 2.1.01.q: Control of VOC and HAP Emissions
- Navy 3.1.04.a: Shipboard Paint and Coating Systems
- Navy 3.1.04.e: Minimize Paint Application Wastes

Federal, state and local environmental agencies such as the EPA and California Air Quality Management Districts (AQMD) classify many VOC's as hazardous and restrict their emissions through regulations such as the Clean Air Act and local EPA and AQMD rules. Chief of Naval Operations (CNO) directives require significant reductions in the amount of hazardous waste generated by the Navy. This technology will satisfy all of these requirements because the SZC is toxic metal free, hazardous air pollutant free, contains no coal tar pitch and is formulated without VOC's.

1.4 Stakeholder/End-User Issues

The Navy and Air Force employ the Navy-developed Unified Facilities Guide Specification (UFGS)-09967 "Coating of Steel Waterfront Structures" whereas the Army, where environmental regulations permit, may use UFGS-09964 "Painting: Hydraulic Structures." However, the Army guidance specifies either three coats vinyl (≈ 780 g/l VOC), three coats epoxy (> 304 g/l VOC) or epoxy top coated with two coats of the coal tar epoxy listed above (VOC's, HAP's, Coal Tar Pitch). The U.S. Army Corps of Engineers (Paint Technology Center, Engineer Research and Development Center, Construction Engineering Research Laboratory), upon acceptable SZC field performance, may modify the Army guidance above or adopt the amended Navy guidance. At present, no additional tests are required by the Army for this effort. In summary, a successful demonstration/validation of the SZC systems followed by an amendment of UFGS 09 97 13.26 will facilitate wide acceptance by the Army as well as the Air Force.

2. TECHNOLOGY DESCRIPTION

2.1 Technology Development and Application

The first liquid polysulfide polymer became commercially available in 1943, thirteen years after the Thiokol Corporation developed and marketed a millable gum polysulfide known as the first synthetic rubber commercially made in the United States. Today, there are several liquid polysulfide polymers, each with distinctly different properties, but similar in chemical structure. To a large extent, products made from liquid polysulfide polymers have the same excellent overall solvent resistance properties as the millable gum polysulfides. However, the liquid polysulfides have the advantage of being room temperature vulcanized, meaning they can be cured at ambient temperatures after the addition of an oxygen donating curing agent (Figure 1).

$$HS(C_2H_4OCH_2OC_2H_4SH)_6C_2\ H_4OCH_20C_2H_4SH$$

FIGURE 1. Disulfide Linkages (Thiol Terminal Groups: -SH).

Liquid polysulfide polymers are classified as high-quality, application-proven products that can be compounded as sealants, adhesives, coating, potting compounds and flexible molding compositions. They are also used for impregnating leather and other porous materials. Compounds based on these polymers are used in industrial and building construction, insulation, glass, aerospace, electronics, aviation, marine and many other industries.

The manufacturing process for liquid polysulfide polymers follows the general method of chemical preparation whereby an organic dihalide is reacted with sodium polysulfide at elevated temperatures. A controlled amount of a trifunctional organic halide, which serves to introduce cross-linking sites, is co-reacted in the process. These cross-linking sites permit a range of elongation and modulus properties of the cured polymer.

Epoxy resins date back to about 1949. Their many excellent properties include rapid curing at normal temperatures, good adhesion to most surfaces, toughness, and chemical resistance to almost all dilute acids, alkalis and solvents. Early uses included heavy-duty industrial paints and structural adhesives in the aircraft industry.

Today, epoxy resin compounds are widely used in construction, marine, electrical and industrial markets. However, in order to meet the different physical properties required for these various markets, certain characteristics of the early epoxy systems have been changed. To make an epoxy flexible, the addition of a liquid polysulfide polymer can be used. The polysulfide addition does improve certain physical properties without adversely affecting the existing performance capabilities of the epoxy resin.

Versatile systems are possible by co-reacting polysulfides with epoxy resins (Figure 2). Liquid Polysulfides (LP) function well as epoxy curatives because of the extreme reactivity of the mercaptide ion created in the presence of an epoxy resin and tertiary amine. The mercaptide ion is formed when the mercaptan donates its hydrogen. The mercaptan ion adds to the epoxide group and displaces the tertiary amine to form a covalent sulfur-carbon bond. The tertiary amine is regenerated and is then available to react with another oxirane group. These systems exhibit the toughness and adhesion of epoxy plus show the improved impact and general chemical resistance of polysulfide.

```
           O                          O
          / \                        / \
     -R-CH-CH2 + HS-R'-SH + H2C-CH-R

             OH                    OH
             |                     |
        -R-CH-CH2-S-R'-S-CH2-CH-R
```

FIGURE 2. **Co-Reaction of Polysulfides with Epoxy Resins.**

Three different epoxy resins can be used with polysulfides: 1) Bisphenol A, 2) Bisphenol F, and 3) Novolac. Each epoxy resin has its own special attributes as follows:

Bisphenol A - low cost, low viscosity, high epoxide content liquid resin ideal for coatings, adhesives, casting, potting, encapsulation, and wet lay-up applications.

Bisphenol F - more expensive, lower viscosity than A, and improved chemical resistance. It is more resistant to inorganic acids than bisphenol A.

Novolac- a high viscosity semisolid to solid resins with multiple functional groups, with increased cross-link density, better physical properties at elevated temperatures, and improved solvent and chemical resistance compared to bisphenol A and F.

Polysulfide polymers, with a glass transition temperature of about -65ºF, remain flexible even at very low temperatures and when subjected to the stresses caused by thermal shock including impact will remain pliant rather than crack or disbond. Through the incorporation of epoxy into the polysulfide backbone, the glass transition temperature does raise but remains flexible even at temperatures below –20ºF.

Application equipment has advanced significantly in recent years. Now, polysulfide materials can be applied without any solvent dilution. Using heated lines, the material is uniformly atomized, giving a smooth coating with good aesthetics. The coating system can now be applied

at up to 100 mils in a single pass. Furthermore, the formulated material allows the coating system to be edge retentive, thus overcoming a long-standing challenge for structural steel and other applications.

According to OSHA's Hazard Communication Standard, LP products are classified as nonhazardous. They are neither eye nor skin irritants, do not cause allergic skin reactions, and are not toxic when administered orally, making LP a safe alternative to amines in curing epoxy systems.

2.2 Previous Testing of the Technology

Commercially available splash zone coatings have been available since the early 1960s and at best continued to display moderate field performance. In 2001, NFESC evaluated commercially available coatings for use in splash zone maintenance, including shop application under simulated marine conditions, and identified distinct contradictions between published marine coating service life and actual field performances (Table 1 and Figure 3).[3]

TABLE 1. 2001 NFESC Assessment of Commercial Splash Zone Coatings.

Property	*Epoxy Putty*	*High Build Epoxy*	*Glass Flake Epoxy*
Installation Ease	Labor Intensive	Standard	Diff. Mixing, Abrad. Nozzles
Film Build	350 mils*	18 mils*	25 mils*
Early Splash Resistance	Good +	Good +	Good
Immersion Cure	Poor +	Good -	Poor
Adhesion: Water-Jet/ Damp Surface	Failed	Good -	Failed
Adhesion: Water-Jet/ Dry Surface	Poor	Good ++	Good+
Adhesion: Blast Profile/ Damp Surface	Poor	Good	Poor

*1000 mils = 1 inch

None of the tested coatings met the desired Navy performance requirements. The two most significant limitations were the inability of the commercial coatings to adequately bond to clean, semi-damp steel and had insufficient curing under immersion (Figure 4). Without proper adhesion or adequate curing, coating systems subjected to cyclic immersion (e.g., splash zone) can lift and typically provide unacceptable corrosion protection. While the high build epoxy may appear to meet all of the requirements, it is still subject to the same UV degradation and therefore lower than desired long term performance.

FIGURE 3. Testing of Commercial SZC. **FIGURE 4.** Failed Epoxy Putty Adhesion.

As a result, in FY 02, NAVFAC's SBIR program solicited the topic entitled "Polysulfide Modified Epoxy Novolac Cladding for Steel Immersion/Splash Zone Service". Subsequently, Phase I and Phase II work were awarded to two contractors: PolySpec Corporation of Houston, Texas, and Polymeright, Inc. of Fremont, California. Phase I results were promising and led to Phase II where results indicate excellent properties for enhanced field performance, including sufficient ease of installation under actual field conditions (Figures 5 to 8).[4,5] Other beneficial Phase II formulation properties include:

- Application; Plural Component Spray (PCS),
- Application thickness; sag free @ 5 mm (200 mils),
- Crack free thickness; > 25 mm (1 inch),
- Cure; wash-out resistant @ 20 minutes,
- Adhesion to Ultrahigh-Pressure Water Jetted (UHPWJ) steel (ASTM-D-4541); > 600 psi (cohesive failure),
- Percent elongation; 20% to 80%,
- Abrasion resistance (ASTM-D-4060); < 30 mg loss @ 1000 revolutions,
- Simulated sea water immersion; < 0.5% weight gain @ 168 hours,
- Cathodic disbondment (NACE RPO394-94: 24-hour test); < 1 mm disbonded radius,
- Compressive strength; > 10,000 psi,
- Edge retentive; > 65% flat surface film thickness retained on edges,
- Volume solids; 100%, and
- Environmentally compliant; HAP's and toxic metal free.

FIGURE 5. PolySpec's Small Scale Installation at Gulf Port, MS.

FIGURE 6. PolySpec's Gulf Port field performance at more than one-year service.

FIGURE 7. Polymeright's Small Scale Installation at San Francisco, CA.

FIGURE 8. Polymeright's CA field performance at more than one-year service.

The SBIR Phase II work concluded in March 2004 and the resulting formulations of polysulfides with epoxy resins are the Zero VOC, Coal Tar Free Splash Zone Coating used in the current demonstration. These products are now commercially available as PolySpec: Thiokol LPE 5100 Splash Zone Coating and Polymeright: CP Chem TZ-R 904.

04/05/05 Field Notes Gulf Port:

- Took 7 weeks to blast section
- Reblasted hours before coating
- One year in service
- Knuckles and edges appear to have the lowest performance/edge retention
- Flat areas look very good
- ~ 40 mils of coating on flat areas

2.3 Factors Affecting Cost and Performance

The primary factors affecting costs will not be so much in the SBIR-developed SZC price per gallon but rather in the costs associated with the overall coating operations such as the following:

- Surface preparation (high pressure water cleaning/power tool grinding/abrasive blasting)
- Wastewater/paint debris containment
- Wastewater/ paint debris collection/treatment/disposal
- High pressure water cleaning equipment
- Plural component paint application equipment (cost increase over other more conventional coatings)
- Surface preparation and application equipment rental or procurement for small scale coating work
- Contained coating operations within a cofferdam in lieu of barge installation
- Various others costs

The cost of the coating material is the smallest consideration in virtually all coating application operations.

The principal factors that could negatively affect the SBIR-developed SZC performance may be as follows:

- SZC installed by contractors not certified to industry standards such as being SSPC QP1 (Society for Protective Coatings) certified
- Inexperienced contractors not trained in the use of Plural Component Spray (PCS) equipment
- Unanticipated moderate corrosion protection, i.e., protection from corrosion product buildup or intermittent protection from CP system when immersed
- Application to improperly prepared surfaces

2.4 Advantages and Limitations of the Technology

Compared to other commercially available SZC's, the main advantages of the SBIR-developed SZC are:

- Compliant with current/future VOC requirements for EPA, State, District and Regional Counties.
- Elimination of environmental fines associated with VOC, HAP's and other regulations.
- Reduced coating removal collection/treatment/disposal costs.
- Reduced facility Total Ownership Cost (TOC).
- Rapid splash zone steel coating maintenance.
- Enhanced waterfront steel corrosion control.
- Flexible, corrosion resistant coating with ability to flex with sea wall movement.

- Maximum adhesion to water blasted steel.
- Impact and abrasion resistant.
- Resistant to cathodic disbondment.
- Ability to cure under water.
- Edge retentive.
- Free of coal tar pitch.

The main limitations of the SBIR-developed SZC are:

- Requires semi-specialized but Commercial Off The Shelf (COTS) surface preparation/application equipment.
- Requires semi-specialized contractor skill.

Table 2 provides another comparison of the commercially available SZCs previously tested (Table 1) to the SBIR-developed SZCs and to a recently developed commercial product, Premier Coating Systems #1200TA, a 100 % solids, glass flake filled epoxy.[6, 7, 8, 9, 10, 11, 21] This PCS coating, selected as the commercial base-line control coating for this demonstration project, represents a second generation high performance marine coating that contains no HAP's, contains no other hazardous chemicals, develops very good adhesion to marginally prepared surfaces (surface tolerant) and complies with future SCAQMD VOC regulations. This new, glass flake filled epoxy coating meets all of the objectives of the demonstration project and the coatings developed under this project. The new commercial coating together with the SZCs developed under this program will provide the baseline performance requirements for a non-government standard.

PCS #1200TA is typically used as a direct-to-metal, surface tolerant, high build, protective maintenance coating. It is used on bulkheads, miter gates, tainter gates, storage tanks and containment, piping, various structural steel and limited concrete surfaces, machinery, plant equipment, marine vessels and barges, offshore structures and other surfaces exposed to humidity, fuel, chemicals and corrosive environments. It is applied using brush, roller, airless spray or plural component spray. The cost per gallon is about $70.00 and is generally applied at approximately 25 mils Dry Film Thickness (DFT) for a material cost of $1.09/SF at 25 mils. Surface preparation and coating application costs for in-service corroding SSP depend upon numerous factors and can start as low as $5.00 SF for Ultra-High Pressure Water Jetting (UHP WJ) followed by $2.00 SF for Airless Spray application. According to these estimates, a conservatively low estimate to install PCS #1200TA to marginally prepared in-service SSP may start at approximately $8.00 SF.

TABLE 2. 2005 Comparison of Splash Zone Coatings

COATING	Splash Zone Coating	Surface Tolerant (adhesion)	Volume Solids	VOC's[1]	HAP's	Other Hazards
Kop-Coat A-788 Epoxy Putty	Yes	Poor-	100 %	≈ 0 g/l	None	Silica, Chrome Green, Carbon Black
Interzone 954 High Build Epoxy	Yes	Good	85 %	163 g/l (Not Met)	> 5 % Xylenes, > 0.05% MIBK	None
Interzone 1000 Glass Flake Epoxy	Yes	Poor-	92 %	75 g/l	> 1 % Xylenes	Silica, if aggregate used
Premier Coating Systems: PCS #1200TA Glass Flake Epoxy	Yes	Good+	100 %	≈ 0 g/l	None	None
PolySpec: Thiokol LPE 5100 Splash Zone Coating	Yes	Excellent	100 %	≈ 0 g/l	None	None
Polymeright: CP Chem TZ-R 904	Yes	Excellent-	100 %	≈ 0 g/l	None	None

1. SCAQMD Rule 1113 < 100 g/l

3. DEMONSTRATION DESIGN

The demonstrations are currently in place at Naval Air Station (NAS) Pensacola, Florida and Naval Station (NAVSTA) San Diego, California. These SZC demonstrations consist of the application of two SBIR-developed SZCs in side-by-side comparisons against each other and to the commercially available control SZC. In San Diego, the three systems were applied to 700 LF x 9.5 LF of properly prepared in-service sheet pile bulkhead (40% coated with Polymeright product, 40% with Polyspec Product and 20% with the control – Premier Coating Systems product). In Pensacola these products were applied in the same proportions to 780 LF x 12 LF of steel sheet pile bulkhead. Because steel sheet pile is angled, the total surface area covered in San Diego was about 10,400 ft^2 and in Pensacola it was about 14,700 ft^2.

3.1 Performance Objectives

Table 3 summarizes performance objectives for the SZC in terms of primary performance criteria and expected performance metrics. In addition to these primary performance objectives, secondary performance objectives are presented in Section 4, Table 4. Performance objectives are further defined in Section 4, Table 5 and include performance criteria, expected performance metric, and confirmation methods.

TABLE 3: Primary Performance Objectives

Type of Performance Objective	Primary Performance Criteria	Expected Performance Metric
Quantitative	Pre-demonstration condition survey for substrate condition and SZC patch employing performance metrics for corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, and **SZC patch test adhesion.**	Meet minimum pre-demonstration condition survey performance criteria as defined in TABLE 5.
Quantitative	Enhanced corrosion protection using performance metrics documenting one-year and four years field performance for corrosion, peeling, blistering, tape adhesion, pull-off adhesion, film thickness, cracking/checking, chalking, biological growth, and dirt pick-up.	Anticipated 50 % increase in service life based upon meeting individual field performance criteria as defined in TABLE 5.

3.2 Selecting Test Platforms/Facilities

California's SCAQMD requires all Architectural and Industrial Maintenance Coatings (AIM), including SZCs, to contain no more than 100 g/l of VOC's. This is the most stringent standard for AIM VOC's. After initial screening of numerous potential sites, four DOD sites with Steel Sheet Piles (SSP) in need of maintenance painting were visually assessed for demonstration suitability; three in California and one in Florida. One of the two demonstration sites selected is

located at the Naval Station (NAVSTA) San Diego, California and the other is at the Naval Air Station (NAS) Pensacola, Florida. Each selected SSP structure was shop coated with two coats of coal tar epoxy and subsequently driven in front of in-place SSP structures. The NAS Pensacola steel sheet piling was put in place in 1980 (Figure 9). The installation date of the San Diego sheet piling (Figure 10) was not determined. After a successful Coating Condition Survey (CCS) as defined in Table 5 was completed, demonstrations were initiated on 14,700 SF of heavily corroded SSP at NAS Pensacola and approximately 10, 400 SF of moderately corroded SSP at NAVSTA San Diego. NAVSTA and NAS personnel, PolySpec, Polymeright and the DOD technical POC's were involved in initiating these demonstrations.

FIGURE 9. Demonstration Site at NAS Pensacola before Coating Application.

FIGURE 10. Demonstration Site at NAVSTA San Diego before Coating Application.

3.3 Test Platform/Facility History/Characteristics

The demonstration sites are located at Bulkhead 303 Pensacola (see Figures 11 and 12) and the quay wall between Piers 1 and 2 San Diego (see Figures 13 and14).[12] Each site is subjected to sea water immersion and splash, moderate to heavy industrial pollution (e.g., acidic fog and dew), biofouling (e.g., mussels, barnacles, algae), and ultraviolet (UV) exposure. These facilities are typical for Naval Facilities which owns about 816 million Square Feet (SF) of seawalls/waterfront bulkheads.[19] Bulkhead 303 Pensacola was reportedly installed in 1980. Underwater facilities inspections are routinely performed for use in quantifying deterioration and scheduling out year mission critical maintenance.[14]

The Naval Air Station Pensacola is located in Escambia County about 5 miles from downtown Pensacola in the westernmost part of the Florida Panhandle. It is situated on a peninsula bounded on the south and east by Pensacola Bay, and on the north by Bayou Grande. According to the "Naval Air Station Master Plan, Naval Complex Pensacola," the mission of the activity is to support units of the Naval Air Training Command and other tenant activities.[13]

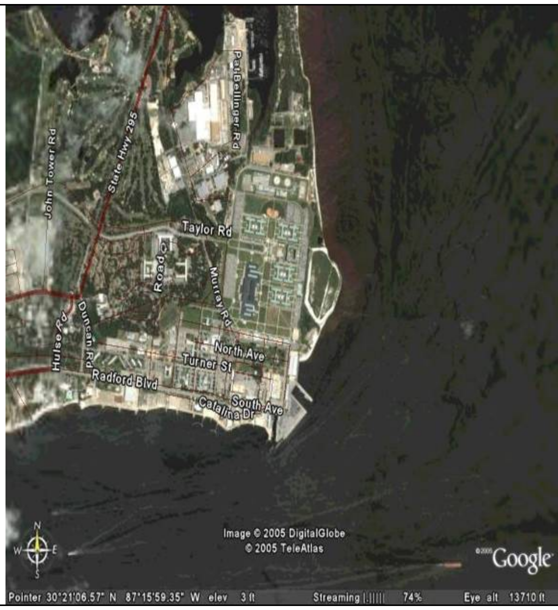


FIGURE 11. Pensacola, FL Site.

FIGURE 12. Bulkhead 303 Pensacola.

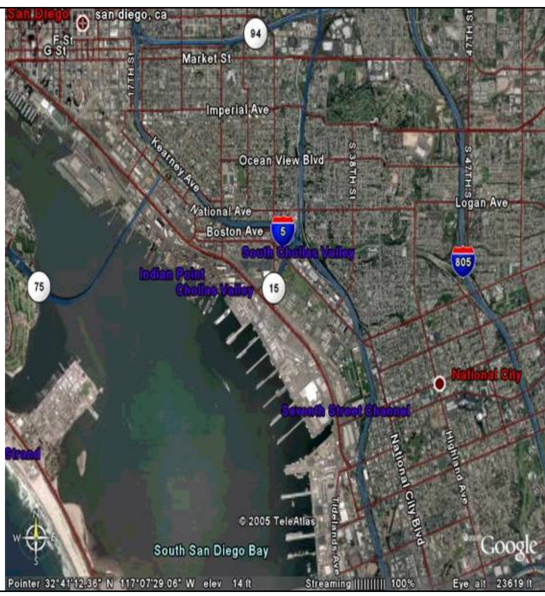


FIGURE 13. San Diego, CA Site.

FIGURE 14. Quay wall between Piers 1 and 2, San Diego.

Naval Station San Diego is located on the Eastern Shore of San Diego Bay about 16.5 miles from the entrance to the Bay[15]. The Naval Station is homeport to approximately 60 Navy ships and to 50 separate commands, each having specific specialized fleet support purposes. The mission of the Naval Station includes ship support and pier berthing space for more than 3,500 ship

movements performed annually[16]. Several facility inspections have been performed for use in assessing the condition Naval Station San Diego waterfront structures.[17, 18]

3.4 Present Operations

Steel sheet piles (SSP), including Bulkhead 303 Pensacola and Quay wall Pier 1/Pier 2 San Diego, initially received one of two coating system options (shop application under controlled conditions) for steel placed in sea water immersion/splash zones as specified in Unified Facilities Guide Specification (UFGS) - 09967 Coating of Steel Waterfront Structures. The coating systems are either three coats epoxy-polyamide or two coats coal tar epoxy-polyamide. Both systems are historically known to provide approximately five years splash zone service before maintenance is required. Maintenance can be localized surface prep and recoat to complete removal and reapplication. However, historically, sheet piles are typically allowed to corrode in place with no coating maintenance employed due to the high cost and environmental concerns that have to be addressed. In addition, neither of these systems is suitable for in-service field maintenance. Therefore, DOD activities typically contact a Protective Coatings Consultant (NAVFAC Paints/Coatings Center of Expertise) for the latest untested State-of-the-Art commercial recommendation. It follows that field activities continue to require a coating system capable of in-service field maintenance such as the current SZCs under demonstration.

3.5 Pre-Demonstration Testing and Analysis

See Section 2.2 “Previous Testing of the Technology” for prior testing and analysis of commercially available alternatives including the SZC. This data could easily be used to provide additional base-line performance data, primarily data from the very small scale field demonstrations (e.g., Gulf Port MS, San Francisco CA), for use in direct comparison to the full-scale demonstration.

3.6 Testing and Evaluation Plan

3.6.1 Demonstration Set-Up and Start-Up

The format and general content of UFGS 09 97 13.26, Coating of Steel Waterfront Structures, provided the basis for demonstration set-up and start-up including requirements for site preparation and utilities for the full-scale demonstrations. UFGS 09 97 13.26 was modified for the full-scale SZC demonstration and subsequently used as the primary installation contract specifications. In addition, the modified UFGS 09 97 13.26 specification contained the “Health and Safety Plan” as presented in Appendix B as well as the “Quality Control Plan” as provided in Appendix C.

3.6.2 Period of Operation

Initial condition surveys at both sites were completed in June 2005. In Pensacola, surface preparation and coating application were started in July 2005 and were 60% completed by late August that year but further work was halted because of Hurricane Katrina. It was not until

August 2006 that surface preparation and coating application operations began anew and finally completed in December 2006. In San Diego, surface preparation and coating applications were completed from February to April 2006. After more than a year of service, coating condition assessments were completed for San Diego in January 2008 and for Pensacola in February 2008.

3.6.3 Amount/Treatment Rate of Material to be treated

Approximately 25,000 SF of in-service failing SSP coating (two demonstration sites) received a combination of the SZC field maintenance coatings (about 20,000 SF requiring about 312 gal of SZC) and the commercial base-line control coating (about 5,000 SF requiring about 78 gal. of the control coating). The amounts are based on theoretical transfer and no losses.

3.6.4 Operating Parameters for the Technology

About 95 % or more of all visible contaminants and remaining coatings from all coated surfaces was removed during surface preparation operations using a combination of hand held water lances classified as Low Pressure Water Cleaning (LPWC) and High to Ultra-High Pressure Water Jetting (UHPWJ). The SZC was applied employing COTS equipment featuring high-pressure, high-volume airless spray with heated delivery hoses and heated mixing pots (e.g., PCS). Industry standards such as those provided by the Society for Protective Coatings (SSPC) were used to document installation and ambient conditions. Standard daily coating field operation parameters were monitored and include

- Air and substrate temperatures,
- Dew point and Relative humidity,
- Surface preparation and installation equipment operating parameters, and
- Resulting level of surface preparation.

3.6.5 Experimental Design

The full-scale demonstration experimental design is essentially the same as the demonstration performance objectives, demonstration performance criteria, expected performance and performance confirmation methods including NTPEP testing, as presented in Table 3, Table 4, and Table 5, respectively. Data collection methods followed a combination of requirements set by industry standards (ASTM, SSPC, etc.).

A noteworthy pre-demonstration condition (as listed in Table 5 under "Primary Criteria") that must be satisfied prior to the full scale demonstration is an SZC patch test adhesion of more than 450 psi supported by a tape test adhesion rating of 4A. The significance and underlying assumption is that a coating's adhesion to a substrate typically reflects degree of surface preparation (e.g., high coating adhesion equates to sufficient surface preparation) and is generally a very good indicator of long-term coating performance.

The primary SZC demonstration events for each of the two SSP structures are sequentially listed as follows:

- quantitative sea wall condition surveys
- corrosion removal using High to Ultra High Water Jetting ($\geq$ 28,000 psi)
- 100 % existing coating removal
- additional abrasive blasting, (not in San Diego)
- stripe coating of angular edges and sheet pile seams/knuckles
- repair of severely corroded metal
- full SZC application employing the 3 test coatings and incidental related work
- containment of coating operations debris
- collection/storage/disposal of generated materials
- adherence to applicable environmental parameters/controls
- quantitative assessment of performance parameters at one year service and
- monitor for a period of up to four years, if resources are available.

Throughout all phases of the field demonstration, specifically surface preparation operations and SZC application, the non-Government demonstration contractor complied with Section 3.6.8 "Health and Safety Plan" and Section 6.1 "Environmental Checklist" provided below. The aforementioned Sections detail minimum contractor compliance requirements for containment measures, contractor employee personnel protection, collection/handling/disposal of coating operations waste, and OSHA requirements. No Federal employees directly participated in assisting the Industrial Painting Contractor with surface preparation and coating operations.

The year one through year four SZC field performance monitoring and assessment reporting will be performed in accordance with "Primary Criteria" as presented in Table 5, headings "One Year Field Performance" and "Four Years Field Performance."

3.6.6 Product Testing

Laboratory testing of the SZC under the American Association of State Highway & Transportation Official's (AASHTO) National Transportation Production Evaluation Program (NTPEP) for "Structural Steel Coating Systems" employing AASHTO Standard Practice R 31-02 consists of the quantitative secondary performance criteria as defined in Table 5 "Expected Performance and Performance Confirmation Methods," below.[20]

A combination of laboratory and field performance data is mandatory since laboratory testing seldom reflects field performance and field performance rarely duplicates accelerated laboratory weathering. Upon successfully meeting the quantitative primary criteria for one-year field performance (see Table 5), the results will be combined with the NTPEP quantitative product testing, classified as secondary performance criteria, to develop a SZC formula/laboratory performance based standard. This is in lieu of an exclusive time-based field performance standard. As such, NTPEP product testing data will support full-scale field demonstration data and provide additional SZC data for use in baseline comparisons.

3.6.7 Demobilization

Following the completion of the full-scale demonstration, the coating contractor restored existing facilities in and around the work areas to their original conditions, including the removal of debris, equipment, materials, temporary connections to Government or Contractor furnished water and electrical services.

3.6.8 Health and Safety Plan

Section 01525 "SAFETY AND OCCUPATIONAL HEALTH REQUIREMENTS" and Section 13283N "REMOVAL/CONTROL AND DISPOSAL OF PAINT WITH LEAD" (where applicable) were part of the demonstration contract and forms the demonstration site "Health and Safety Plan." These Sections are currently titled UFGS 01 35 29 "SAFETY AND OCCUPATIONAL HEALTH REQUIREMENTS" and UFGS 02 82 33.13 20 "REMOVAL / CONTROL AND DISPOSAL OF PAINT WITH LEAD". To ensure additional "Health and Safety Plan" compliance, the Industrial Painting Contractor was certified by the Society for Protective Coatings (SSPC) to:

- SSPC QP-1 "Standard Procedure for Evaluating the Qualifications of Painting Contractors Performing Industrial Surface Preparation and Coating Application in the Field."
- SSPC QP-2 "Standard Procedure for Evaluating the Qualifications of Painting Contractors to Remove Hazardous Paint," and

3.7 Selection of Analytical/Testing Methods

Refer to Table 5 "Expected Performance and Performance Confirmation Methods" for primary and secondary testing methods, expected performance metrics, and the individual standards for use as performance confirmation.

3.8 Selection of Analytical/Testing Laboratory

Laboratory testing of the SZC under AASHTO's NTPEP program was performed by KTA-Tator, Inc. of Pittsburgh, PA; the exclusive certified AASHTO-Select Test Facility. Under the completed SBIR efforts, each contractor performed third party laboratory testing by The Coatings Laboratory of Houston, TX, and Chevron Phillips Chemical Company LP of Woodlands, TX. Additional analytical laboratory support for use with formulation and physical properties may continue to be required from the aforementioned labs. Furthermore, wastes generated from routine coating operations may require analytical classification and work of this nature will be contracted to a local analytical laboratory.

3.9 Management and Staffing

Mr. C. David Gaughen, Naval Facilities Engineering Service Center (NFESC), will coordinate

the ESTCP project and personally develop the Master Painters Institute (MPI) Detailed Performance Standard (DPS) and amend Unified Facilities Guide Specification (UFGS) - 09967 “Coating of Steel Waterfront Structures.” Mr. Jason Bell of PolySpec and Mr. Alex Vainer of Polymeright will oversee their proprietary SZC production, delivery, contractor certification, and installation quality control. Ms. Susan Drozdz will confirm work meets US Army requirements and Ms. Nancy Coleal will confirm work meets US Air Force requirements. Mr. Bob Welch of MPI will oversee and approve the MPI DPS and all UFGS work will be coordinated through the Naval Facilities Engineering Command (NAVFAC) Engineering Innovation and Criteria Office (Code EICO). Mr. David Gaughen will also act as the Quality Assurance (QA) officer and a wiring diagram depicting the simplistic managerial hierarchy above is not required.

3.10 Demonstration Schedule(s)

A. NAS PENSACOLA DEMONSTRATION SCHEDULE

PENSACOLA FL: 2005/2006	March	July	August	2006 / Sept	Oct	Nov	Dec
Perform Bulkhead Condition Survey							
Develop SZC Demonstration Contract							
Award Demonstration Contract							
Contractor Kick-Off Meeting							
Demonstration Initiated**							
Document Demonstration**							
Demonstration Completed							

**Work delay due to Hurricane Katrina.

B. NAVSTA SAN DIEGO DEMONSTRATION SCHEDULE

SAN DIEGO CA: 2005-2006	August	Nov	Dec	Jan	Feb	March	April
Perform Bulkhead Condition Survey							
Develop SZC Demonstration Contract							
Award Demonstration Contract							
Contractor Kick-Off Meeting							
Demonstration Initiated							
Document Demonstration							
Demonstration Completed							

4. PERFORMANCE ASSESSMENT

4.1 Performance Criteria

Table 4 presents general performance criteria for the three SZC products included in the demonstrations at both the Pensacola and San Diego sites. The table includes criteria for Pre-Demonstration, Field Performance, Product Testing, Factors Affecting Technology Performance, Reliability, Ease of Use, Maintenance, Scale-Up Constraints, Reduced Painting Operations Debris/Waste and Reduced Hazardous Materials. Testing, under AASHTO's NTPEP program, will be performed concurrently with the demonstration; results of formula, laboratory performance, and field performance testing will be correlated to demonstration performance for use in developing specification standards for the SZC.

TABLE 4: Performance Criteria

Performance Criteria	Description	Primary or Secondary
Pre-Demonstration ●Condition of Demonstration Site	Must meet minimum pre-demonstration criteria as defined by ASTM standards presented in TABLE 5	Primary
Field Performance ●One Year and Four Years	Must meet minimum field performance criteria as defined by ASTM standards presented in TABLE 5	Primary
Product Testing ●Formula ●Laboratory Performance	Must meet minimum Individual ASTM standards for NTPEP testing presented in TABLE 5	Secondary
Qualitative Factors	Must meet factors defined in TABLE 5.	Secondary

4.2 Performance Confirmation Methods

In addition to the reduction of VOC emissions and overall environmental compliance, a successful SZC maintenance painting demonstration will be readily apparent at one-year field performance and more so at four years field performance. Table 5 "Expected Performance and Performance Confirmation Methods" quantitatively defines acceptable one-year and four years field performance metrics for use in documenting the SZC for corrosion, peeling, adhesion, film thickness, cracking/checking, chalking, blistering, biological growth, and overall aesthetics.

To ensure a successful demonstration, Appendix B "Data Quality Assurance/Quality Control Plan" details quality assurance for the laboratory tests, quality assurance for the SZC contractor, quality assurance for the field tests and inspection, and the quality control plan employing UFGS-01450N "Construction Quality Control."

TABLE 5: Expected Performance Metrics and Confirmation Methods

Performance Criteria	Expected Performance Metric	Performance Confirmation Method
PRIMARY CRITERIA (Quantitative)		
Pre-Demonstration		
Coating Condition Survey		
- Corrosion	No more than 30 % metal loss	ASTM D 610 (% of total surface area)
- Peeling	No more than 15 % peeling	ASTM D 610 (% of total surface area)
- Blistering	No more than 15 % blistering	ASTM D 610 (% of total surface area)
- Tape Adhesion	Document Adhesion	ASTM D 3359 (> 3 tests)
- Pull-Off Adhesion	Document Adhesion	ASTM D 4541 (> 3 tests)
- Film Thickness	No more than 20 mils	ASTM D 4138, SSPC PA-2
- Metal Thickness	At least 0.25 in.	Metal Thickness Gauge
- SZC Patch Test Adhesion	More than 450 psi and > 4A	ASTM D 3359, D 4541 (3 tests)
One-Year Field Performance	NOT YET COMPLETED	
- Corrosion	No more than 0.1 % corrosion	ASTM D 610 (% of total surface area)
- Peeling	No more than 0.1 % peeling	ASTM D 610 (% of total surface area)
- Blistering	No more than 0.1 % blistering	ASTM D 610 (% of total surface area)
- Tape Adhesion	No less than 4A	ASTM D 3359 (> 3 tests)
- Pull-Off Adhesion	More than 450 psi	ASTM D 4541 (> 3 tests)
- Film Thickness	Report Thickness	ASTM D 4138, SSPC PA-2
- Cracking/Checking	No less than 8	ASTM D 660, ASTM D 661
- Chalking	No less than 8	ASTM D 4214 (% of total surface area)
- Biological Growth	No less than 8	ASTM D 3274 (% of total surface area)
- Dirt Pick-Up	No less than 8	ASTM D 3274 (% of total surface area)
Four-Years Field Performance	NOT YET COMPLETED	
- Corrosion	No more than 0.3 % corrosion	ASTM D 610 (% of total surface area)
- Peeling	No more than 0.3 % peeling	ASTM D 610 (% of total surface area)
- Blistering	No more than 0.3 % blistering	ASTM D 610 (% of total surface area)
- Tape Adhesion	No less than 3A	ASTM D 3359 (> 3 tests)
- Pull-Off Adhesion	More than 110 psi	ASTM D 4541 (> 3 tests)
- Film Thickness	Report Thickness	ASTM D 4138, SSPC PA-2
- Cracking/Checking	No less than 8	ASTM D 660, ASTM D 661
- Chalking	No less than 8	ASTM D 4214 (% of total surface area)
- Biological Growth	No less than 8	ASTM D 3274 (% of total surface area)
- Dirt Pick-Up	No less than 8	ASTM D 3274 (% of total surface area)
SECONDARY CRITERIA (Quantitative): MSDS's/product descriptions have some formula info but this is not confirmed by NTPEP		
NTPEP SZC Testing (R 31-02) ●Formula		

- Color - VOC - Total Solids (wt) - Total Solids (volume) - Percent Pigment - Stormer Viscosity - Brookfield Viscosity - Pot Life - Sag Resistance - Theoretical Coverage - Drying Times - Mixing Ratio - Shelf Life - Infrared Analysis - Heavy Metals - Dry Film Leachable Metals - Epoxide Value - Amine Value	Property Documented No more than 50 g/l Property Documented Property Documented Property Documented Property Documented Property Documented Property Documented No less than 7 mils Property Documented Properties Documented Property Documented Property Documented SZC Fingerprint Free of Chromium, Lead Free of Arsenic, Mercury, Silver Property Documented Property Documented	Fed. Std. 595, ASTM D 2244 ASTM D 2369 ASTM D 2369 ASTM D 2697 ASTM D 2371 ASTM D 562 ASTM D 2196 N/A ASTM D 4400 N/A ASTM D 1640 N/A N/A N/A ASTM D 3335 TCLP/EPA SW 846 ASTM D 1652 ASTM D 2073
●Laboratory Performance - 4,000 hrs Salt Fog Resistance - 336 hrs Cyclic Weathering - Abrasion Resistance - Adhesion Testing - 30 Day Freeze Thaw Stability	 Performance Documented Performance Documented Performance Documented Values Documented Performance Documented	 ASTM B 117, ASTM D 1654 ASTM D 5894 ASTM D 4060 ASTM D 4541 AASHTO R 31-02
●Atmospheric Testing - 2 Years Exposure	 Performance Documented	 Severe Marine Exposure, Quantitative Panel Evaluation

SECONDARY CRITERIA (Qualitative)		
A Key Factor Affecting Technology Performance	A key factor in the success of any coating is surface preparation. In the case of steel sheet piling in the splash zone and below this is especially true. Cofferdam construction, debris collection requirements, saltwater proximity, and tidal changes make surface preparation in the intertidal area extremely	Document level of surface preparation for each of the three coatings applied at both sites.

	difficult. These factors should be the same for each of the coatings applied because any variation in surface preparation will have a profound effect on cost and, more importantly, relative performance.	
Reliability	Reliability should be higher than routine maintenance painting employing traditional coating materials. The Primary Criteria will provide short term measurable results but time between maintenance requirements will provide the long term field results.	Document installation sequence and QA/QC processes including those for the control coating. Determine how well the substrate is protected by measuring when and how often maintenance is required. The Primary Criteria results will provide supporting documentation.
Ease of Use	Equal level of contractor competence is required as minimum qualifications for SZC installation. The Society for Protective Coatings (SSPC) QP-1 contractor certification is recommended. The new technology was developed for use with a Commercially-Off-The-Shelf (COTS) plural component spray rig: however, special operator skill throughout spraying is required to ensure controlled mixing/uniform application and two spray equipment operators are required during use.	Document operator experience and report operator comments.
Maintenance	Maintenance of the SZC should require a level of maintenance less than routine corrosion prevention on Steel due to enhanced barrier protection.	Document one and four year field performance as compared to the control.
Scale-Up Constraints	The demonstration was performed at full-scale using	Scale-up confirmation not necessary.

	COTS surface preparation and SZC application equipment.	
Reduced Painting Operations Debris/Waste	Collection/disposal wastes should be reduced by 25% via increased coating service life.	Since a reduction is based on increased service life – document one and four year field performances.
Reduced Hazardous Materials	Reduced SZC formulation hazardous materials by 95% as compared with coatings employed in UFGS 09 97 13.26.	Compare test formulations with UFGS 09 97 13.26 coatings formulations.

4.3 Data Analysis, Interpretation and Evaluation

Table 6 shows the pre-demonstration coating condition survey results for both the Pensacola and San Diego demonstration sites. Since the expected performance metric for the existing Pensacola coating was not met (Table 6), the sea wall surfaces (Figure 15) were prepared by water blasting followed by grit blasting (Figure 16). This assured adequate adhesion of the applied coatings. The surface in San Diego (Figure 17) was prepared for remedial coating by water blasting only (Figure 18). Metal thickness was measured to assure enough metal remained to make remedial coating worthwhile and as a baseline to determine any long-term corrosion as indicated by metal thickness loss.

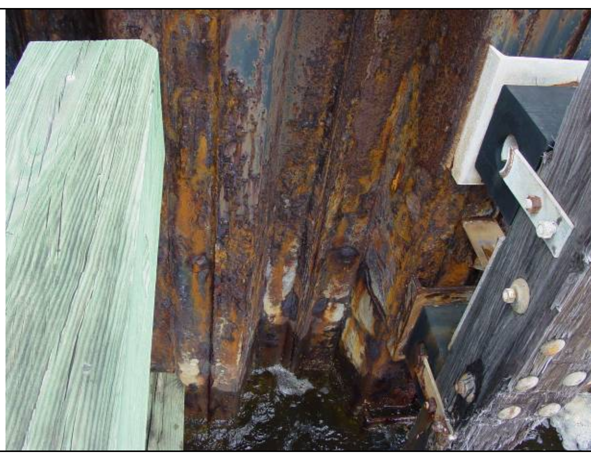
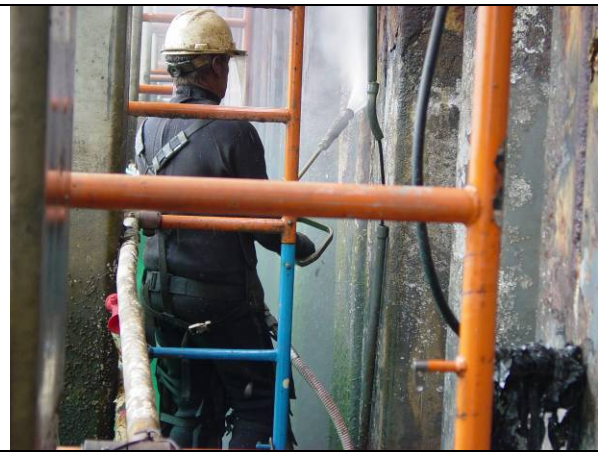


FIGURE 15. Typical corrosion on Pensacola steel sheep pile before surface preparation.

FIGURE 16. Pensacola steel sheet pile surface preparation.

	
FIGURE 17. Typical corrosion on San Diego steel sheet pile before surface preparation.	**FIGURE 18.** San Diego steel sheet pile surface preparation.

The most critical data of Table 6 are the SZC patch adhesion results (Figures 19 and 20). The patch test coatings were applied within an hour after blast cleaning but flash rust occurred within 20 minutes after blasting (Figures 21 to 24). In both Pensacola and San Diego the control coating (PCS #1200TA) performed somewhat poorly with low adhesion (290 and 243 psi, respectively). This is in contrast to the test coatings of Polymeright (398 and 380 psi, respectively) and Polyspec (486 and 435 psi, respectively). Only the Polyspec product in Pensacola met the expected performance metric. Since a coating's adhesion to a substrate typically reflects degree of surface preparation and is generally a very good indicator of long-term coating performance, this patch test bodes well for the future performance of the Polyspec test coating.

	
FIGURE 19. Typical test patch – Premier coating system on Pensacola steel sheet pile.	**FIGURE 20.** Typical test patch – PolySpec coating on San Diego steel sheet pile.

FIGURE 21. Typical appearance of Pensacola SSP just after surface preparation.

FIGURE 22. Pensacola SSP after flash rusting and before coating application.

FIGURE 23. Typical appearance of San Diego SSP just after surface preparation.

FIGURE 24. San Diego SSP after flash rusting and before coating applications.

After successful patch tests, surface preparations and coating applications were completed in both San Diego and Pensacola. In contrast to the patch test coatings which were applied within an hour of surface preparation, the full coatings were applied hours to days after cleaning (Figures 25 and 26).

FIGURE 25. Coating Application on Pensacola steel sheet piling.

FIGURE 26. Coating Application on San Diego steel sheet piling.

TABLE 6: Pre-Demonstration Survey Results: Expected Performance Metrics and Actual Performance at Pensacola and San Diego Test Sites.

Performance Criteria	Expected Performance Metric	Actual Performance	
Existing Coating Condition Survey		**Pensacola**	**San Diego**
- Corrosion - Peeling - Blistering - Tape Adhesion - Pull-Off Adhesion - Film Thickness - Metal Thickness	≤ 30 % metal loss ≤ 15 % peeling ≤ 15 % blistering NA NA ≤ 20 mils ≥ 0.25”	~ 3/8” avg. rust scale 65 - 90% 70 - 90% 3A - 4A 95 psi avg. 7 - 30 mils 1999 report: ~38% max. metal loss at web; web 0.25 – 0.32”; ~8% metal loss at flange; 0.46 – 0.54” 10/12/06 tests: 0.524 – 0.530” outer, 0.276 – 0.387” angle, and 0.489 – 0.517” inner	3/24/05 notes - 7% coating failure; 5% corrosion; 20% metal loss at pits max.; 12% metal at coating failure.

Pensacola Patch Tests		**PCS**[1]	**PR**[2]	**PS**[3]
- SZC Patch Adhesion	> 450 psi > 4A	290 psi avg. 5A	398 psi avg. 4A – 5A	486 psi avg. 5A
San Diego Patch Tests		**PCS**[1]	**PR**[2]	**PS**[3]
- SZC Patch Adhesion	> 450 psi > 4A	243 psi avg. 5A	380 psi avg. 3A – 5A	435 psi avg. 5A

[1] Premier Coating Systems: PCS #1200TA
[2] Polymeright: CP Chem TZ-R 904
[3] PolySpec: Thiokol LPE 5100 Splash Zone Coating

TABLE 7: One Year Coating Condition Survey Results: Expected Performance Metrics and Actual Performance at Pensacola and San Diego Test Sites.

Performance Criteria	Expected Performance Metric	Actual Performance					
		Pensacola			San Diego		
		PCS[1]	PR[2]	PS[3]	PCS[1]	PR[2]	PS[3]
- Corrosion	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %
- Peeling	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %
- Blistering	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %	≤ 0.1 %
- Tape Adhesion	≥ 4A[4]	NA	NA	NA	NA	NA	NA
- Pull-Off Adhesion	> 450 psi[4]	NA	NA	NA	NA	NA	NA
- Film Thickness	NA	NA	NA	NA	NA	NA	NA
- Cracking/Checking	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8
- Chalking	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8
- Biological Growth	≤ 8[5]	≤ 8, NI	≤ 8, NI	≤ 8, NI	≤ 8, NI	≤ 8, NI	≤ 8, NI
- Dirt Pick-Up	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8	≤ 8

1. Premier Coating Systems: PCS #1200TA
2. Polymeright: CP Chem TZ-R 904
3. PolySpec: Thiokol LPE 5100 Splash Zone Coating
4. Both are destructive tests and not performed.
5. No impact on the coating system / substrate.

First year survey report attached as Appendix C.

SECONDARY CRITERIA				
NTPEP SZC Testing (R 31-02)				
●Formula				
- Color	NA			
- VOC	≤ 50 g/l			
- Total Solids (wt)	NA			
- Total Solids (volume)	NA			
- Percent Pigment	NA			
- Stormer Viscosity	NA			
- Brookfield Viscosity	NA			
- Pot Life	NA			
- Sag Resistance	≥ 7 mils			
- Theoretical Coverage	NA			
- Drying Times	NA			
- Mixing Ratio	NA			
- Shelf Life	NA			
- Infrared Analysis	SZC Fingerprint			

- Heavy Metals - Dry Film Leachable Metals - Epoxide Value - Amine Value ●Laboratory Performance - 4,000 hrs Salt Fog Resistance - 336 hrs Cyclic Weathering - Abrasion Resistance - Adhesion Testing - 30 Day Freeze Thaw Stability ●Atmospheric Testing - 2 Years Exposure	Free of Chromium, Lead Free of Arsenic, Mercury, Silver NA NA NA NA NA NA NA NA			

SECONDARY CRITERIA (Qualitative)		
Factor Affecting Technology Performance	Level of surface preparation equal for all three coatings	Document operator experience and/or on-site training. [in notebooks]
Reliability	Reliability higher than routine maintenance painting employing traditional coating materials.	Document installation sequence and QA/QC processes including those for the control coating. [in notebooks]
Ease of Use	Contractor Friendly	Document operator experience and report operator comments. [in notebooks]
Maintenance	Reduction in scheduled maintenance cycles.	Document one and four year field performance as compared to the control. [First year complete.]
Scale-Up Constraints	Demonstration performed at full-scale using COTS surface preparation and	Document operator experience and/or on-site training, installation sequence and QA/QC processes. [no need to document]

	SZC application equipments.	
Reduced Painting Operations Debris/Waste	25% reduction.	Document/report collection/disposal wastes. [in notebooks]
Reduced Hazardous Materials	95% hazardous material reduction.	Compare/calculate against coatings employed in UFGS 09 97 13.26. [comparison of formulations]

If the Primary Criteria (quantitative) for one-year field performance from Table 5 is met, then NTPEP Secondary Performance Criteria (quantitative) will be used to develop a SZC formula/laboratory performance based standard, in lieu of a standard based on timely field performance. It is anticipated, based upon small scale field demonstrations of the SZC, that much more than a minimum of one-year field performance will be achieved. As such, NTPEP laboratory data supported by actual field performance will transition into a new SZC commercial standard for use in amending UFGS 09 97 13.26 “Coating of Steel Waterfront Structures.”

5. COST ASSESSMENT

$120K contracts each to Polymeright and PolySpec extended to Sep 2006 for San Diego work only.

$345K Contract Awarded Techno Coatings for San Diego Demonstration – administered through S&K Technologies. QA/QC performed by Dave Gaughen ~$46K cost.
Total Project Cost about $391K for 700 LF
10,400 actual SF of surface = **$37.60 per Square Foot**

PENSACOLA:
06/2005: by Ellis Environmental for Bulkhead 303

- $151K proposed for surface preparation.
- $85.5K for epoxy application.

Contract Awarded Madcon Corp. for Pensacola Demo Subcontracts. Subcontract awarded to Ercon, Ellis Environmental - Awarded by Pensacola NAS/ROICC – N62467-05-D-0067.

9/15/06: Total revised actual cost was $336K; this includes modifications due to delays.

$151K QA/QC Cost - Dave Gaughen
+ $166K direct support of MADCON expenses by NFESC
+ Total Revised Contract Cost.
= Total Project Cost about $653K.

14,700 actual SF of surface = **$44.42 per Square Foot**

For Comparative Purposes – Wake Island Fueling Pier Repair Cost Estimate Sep 2005:
Steel Sheet Piling Splash Zone Coating = $396K for 205 LF bulkhead x 12.7 ft (MLLW to top of sheet piling). Total actual surface area about 4,090 SF = **$96.82 per SF** (about 50% of cost attributed to remote location).

For Comparison:

Aug 21, 2001: General Construction Co., Poulsbo, Wash., is being awarded an $8,745,173 firm-fixed-price contract for the temporary shutdown for repair of the Paleta Creek Fendering System and Quay wall at Naval Station San Diego. Work will be performed in San Diego, Calif., and is expected to be completed by September 2003. Contract funds will expire at the end of the current fiscal year. This contract was competitively procured with 117 proposals solicited and six offers received. The Naval Facilities Engineering Command, Southwest Division, San Diego, Calif., is the contracting activity (N68711-98-C-5416).
LF = ~3,150 Cost for Quay wall Repair only ~ $6.5M = **~$2,063 per LF**

Sep 24, 2003: Marathon Construction Corporation*, San Diego, Calif., is being awarded a $16,770,000 firm-fixed-price contract for repair of Chollas Creek Fender System and Quay wall at Naval Station San Diego and Fender Piles (Phases I and II) at Naval Amphibious Base Coronado. Work will be performed in San Diego and Coronado, Calif., and is expected to be completed by May 2006. Contract funds will expire at the end of the current fiscal year. This contract was competitively procured with 45 proposals solicited and six offers received. The Naval Facilities Engineering Command, Southwest Division, San Diego, Calif., is the contracting activity (N68711-03-C-3707).

NAVSTA San Diego, John Dye ROICC (619-556-0481)
Sheet Pile Installation Costs $16,770,000 in front of existing concrete sheet piles, includes new concrete cap, some repairs to existing concrete. New sheet piling coated with coal tar.

LF = ~ 4,720 Cost for Quay wall Repair only ~ $11.5M **= ~$2,436 per LF**

5.1 Cost Reporting

The primary objectives of the detailed cost assessment is to document, develop and validate the expected costs of implementing a real-world SZC painting option for use on multiple SSP and/or steel waterfront structures requiring additional corrosion protection utilizing environmental compliant coatings. To begin, direct and indirect SZC full-scale field demonstration costs will be documented and analyzed using a combination of cost assessment tools such as Impact Analysis[22], the Environmental Costs Analysis Methodology (ECAM), trade industry estimating guidance[23, 24, 25], field activity based costing methodology, and the tracking of actual demonstration costs, including direct line item submittal costs from the SZC installation contractor. However, after all the labor intensive cost assessment work is complete, custodians of steel waterfront structures requiring maintenance painting will decide whether to employ the environmentally compliant SZC based primarily on a comparison of the Cost Per Unit Area (CPUA) supported by the anticipated years of service when compared directly to costs and performance associated with waterfront structure removal and a new waterfront structure installation.

First, the actual full-scale field demonstration costs will be reported followed by estimated costs associated with annual SZC maintenance painting of multiple SSPs. For example, direct costs for activity funded SZC field painting can include the containment system, wastewater and paint debris collection/treatment/disposal, environmental monitoring, total surface area requiring welded metal spot repairs (repairing holes in SSP), number of workers and worker hours per stage of work, labor hours including benefits, material costs, equipments costs, overhead costs, and several others. All indirect environmental cost and other costs will be identified, reported and subsequently evaluated.

Table 8 will be used to report costs for the SZC using subheadings with greater detailing provided for the category entitled "Installation." A similar table of costs associated with the current technology and/or competing alternate technologies may also be developed. A

comparison of these tables will simplify the decision making process for all custodians of steel waterfront structures requiring painting for corrosion control.

TABLE 8: EXAMPLES OF TYPES OF COSTS BY CATEGORY							
Direct Environmental Activity Process Costs							
Direct Start-Up Costs		**Direct Operation & Maintenance**		**Indirect Environmental Activity Costs**		**Other Costs**	
Activity	$	Activity	$	Activity	$	Activity	$
Equipment purchase	0	Labor to operate equipment	0	Compliance audits	0	Overhead assoc. with process	1K
Equipment design	0	Labor to manage hazardous waste	0	Document maintenance	1K	Productivity/Cycle time	0
Mobilization	0	Utilities	2K	Environmental Management Plan development & maintenance	0.5K	Worker injury claims & health costs	0
Site preparation	0	Mgmt/Treatment of by-products	0	Reporting requirements	0		
Permitting	0	Hazardous waste disposal fees	0	Test/analyze waste streams	0		
Installation* -- surface preparation -- material costs -- paint application -- containment -- disposal -- environ. monitoring -- worker health -- labor -- overhead/misc. -- tools/equipment -- other	198K	Raw materials	0	Medical exams (including loss of productive labor)	0		
Training of operators	0	Process chemicals, Nutrients	0	Waste transportation (on and off-site)	0		
		Consumables and supplies	0	OSHA/EHS training	0		
		Equipment maintenance	0				
		Training of operators	0				

*one-time painting contractor installation costs per 10,000 SF of SSP; cost represents a lump sum figure that includes all materials, coating installation and waste disposal fees.

5.2 Cost Analysis

A cost comparison will be performed to evaluate the environmentally compliant SZC as compared to complete structure removal/new structure installation employing coatings similar to those specified in UFGS 09 97 13.26, and potentially compared to emerging coatings at multiple

sites throughout the Navy. The comparison may take into consideration the annual economic and environmental considerations of the proposed alternative versus the existing process.

In addition to the analysis of all one-time installation costs, the cost analysis, which includes cost basis, cost drivers, and life cycle cost estimating, could be similar in content and analysis to that performed by Kevin J. Kovaleski in his Cost and Performance Report for the project entitled "Demonstration/Validation of a Zero-VOC Waterborne Polyurethane Topcoat" as highlighted below:

- The *payback* (in years) shows how quickly the Navy could realize recovery of the investment. If there are no investment costs for the new technology as is the case for this replacement, and the annual savings are positive, there will always be an "immediate" payback on the investment.
- The *net present value* shows the total cash benefit in today's dollars of the investment, and is the best economic metric to compare alternatives to each other. Some technologies are material or business practice change only and hence do not entail an investment by the facility or using command; therefore, there is no payback or Internal Rate of Return (IRR), so the only useful economic metric is net present value. The net present value is determined for an investment life of a determined set of years.
- The *TRI chemical reduction* (annual) shows the amount of chemicals (lbs) on the Superfund Amendment and Reauthorization Act (SARA) Title III list that would be reduced from release into the environment. The analysis may include two charts showing reductions at the baseline site, and reductions for the enterprise wide deployment.
- The *HazMat reduction* (annual) could show the reduced amount of material inventory containing the TRI chemicals, indicating reduced hazardous material inventory control and Toxic Release Inventory (TRI) reporting workload.
- The *Hazardous Waste reduction* (annual) may show the reduced amount of waste disposal, indicating reduced contract services costs, waste handling and reporting, and associated risks.

6. IMPLEMENTATION ISSUES

6.1 Environmental Checklist

All surface preparation liquid and paint debris waste is to be contained, collected, stored and analyzed for hazardous material concentrations prior to appropriate disposal.

The demonstration plan Industrial Painting Contractor will be required to comply with Federal, State and Local environmental regulations throughout all aspects of the full-scale demonstration as further defined in the following Sections of the demonstration plan installation contract: 1) Section 01525 "SAFETY AND OCCUPATIONAL HEALTH REQUIREMENTS," 2) Section 01572 "CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT," 3) Section 01575N "TEMPORARY ENVIRONMENTAL CONTROLS," 4) Section 01770N "CLOSEOUT PROCEDURES," 5) Section 02120A "TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS," 6) Section 09967 "COATING OF STEEL WATERFRONT STRUCTURES," and 7) Section 13283N "REMOVAL/CONTROL AND DISPOSAL OF PAINT WITH LEAD," if applicable. As a result of Florida's Hurricane Ivan, the majority of environmental permits associated with construction work at NAS Pensacola's are presently exempt from filing; however, the NAVSTA San Diego may require a base approved Notice of Intent (e.g., regional waste water discharge), Environmental Plan and a site specific Safety Plan.

6.2 Other Regulatory Issues

A regulatory representative from either the SCAQMD of California at Los Angeles or a southern California district representative of the Environmental Protection Agency (EPA), or both, may be contacted for participation in the project demonstration in San Diego.

6.3 End-Users/Original Equipment Manufacturers (OEM) Issues

Concerns, reservations, and decision-making factors affecting SZC buy-in from DOD end-users will be at a minimum since technical POC's from the Navy, Army and Air Force will review and subsequently approve all guidance documents in advance of submission to NAVFAC's Engineering Innovative Criteria Office (EICO) for guidance inclusion on the Construction Criteria Base's (CCB) web site at http://www.ccb.org . The full-scale SZC demonstration(s), including the NTPEP testing, will confirm acceptable SZC performance prior to drafting new DOD guidance.

PolySpec L.P. has sales in excess of $10M/year and large volume production, including international sales and distribution to locations outside the continental USA, is performed daily. Polymeright, Inc. has developed a joint partnership for coating commercialization with Chevron Phillips Chemical Company LP, a multi-billion dollar international corporation. As such, manufacturing including SZC distribution is not a significant concern.

Procurement of the SZC will be specified in the amended UFGS under Section 2, "PRODUCTS" using a combination of performance and formulation properties presented in a table or by reference to a new Master Painters Institute (MPI) Detailed Performance Standard (DPS) developed exclusively for the SZC. DPS is being developed. Referencing either the new MPI DPS or presenting formulation and performance testing requirements within the new specification is sufficient to enable other coating manufacturer's to compete for SZC sales and eliminates the requirement of sole source SZC procurement. As such, SZC procurement will then become a required contractor's material submittal when preparing a bid for work to perform corrosion control on an SSP requiring maintenance painting. Within the new UFGS under Section 3, "EXECUTION" commercially-off-the-shelf (COTS) surface preparation equipment and SZC application equipment is commercially available and all equipment will be required to meet performance requirements set by the SZC manufacturers as well as UFGS specification requirements.

To reiterate, demonstration results will transition into commercial guidance such as a new Master Painters Institute (MPI) Detailed Performance Standard (DPS) for the SZC followed by amending the Unified Facilities Guide Specification (UFGS) entitled "Coating of Steel Waterfront Structures." The DPS and the UFGS will be web-displayed at http://www.paintinfo.com , http://www.ccb.org/ufgs/ufgs.htm , respectively, and for direct use by Tri-service activities with AST's in need of maintenance painting. In addition to the above, PolySpec L.P. and Polymeright, Inc., will continue to produce and market the SZC to the OEM community including the Bureau of Reclamation and to state Department of Transportation (DOT's). Other applications of the SZC may include bridges, offshore structures, structural steel, antenna towers, and various concrete structures.

7. REFERENCES

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2. http://www.aqmd.gov/rules/rulesreg.html .

3. C. David Gaughen. 2002. *Coatings for Splash Zone Maintenance.* Waterfront Integrated Product Team (IPT). January 2002.

4. Paul Anderson and Jason Bell. 2004. *Polysulfide Modified Epoxy Novolac Cladding for Immersion/Splash Zone Service,* SBIR Phase I/II Contract #N47408-02-R-2312, February 2004. 2001.

5. Leonid Rappoport, Alex Vainer and Alex Yam. 2004. *Polysulfide Modified Epoxy Novolac Cladding for Immersion/Splash Zone Service,* SBIR Phase I/II Contract #N47408-02-C-7305, March 2004.

6. Premier Coating Systems, Inc. *MSDS & Product Literature for PCS #1200TA.* 2004.

7. PolySpec. *MSDS & Product Literature for Thiokol LPE 5100 Splash Zone Coating.* 2005.

8. Polymeright, Inc. *MSDS & Product Literature for CP Chem TZ-R 904.* 2005.

9. International Protective Coatings. *MSDS & Product Literature for Interzone 954 (High Build Epoxy). 2004.*

10. International Protective Coatings. *MSDS & Product Literature for Interzone 1000 (Glass Flake Epoxy). 2004.*

11. Carboline. *MSDS & Product Literature for Kop-Coat A-788 (Epoxy Putty). 2004.*

12. Contract Report. 1995. *Underwater Inspection of Facilities at Naval Air Station, Pensacola, FL.* NFESC EAST COAST DET. CR-6009-OCN. November 1995.

13. Ibid.

14. Contract Report. 2000. *Underwater Inspection of Facilities at Naval Air Station, Pensacola, FL.* NFESC EAST COAST DET. CR-6152-OCN. February 2000.

15. NFESC Waterfront Materials Division. 2001. *Above Water Control Inspections and Assessments of Piers 1, 3, 5, 7, and 13, Naval Station San Diego and Fuel Pier and Piers 1, 3, 5, 7, 11, 13, 17, and 19, Naval Amphibious Base, Coronado.* SSR-2639-SHR. June 2001.

16. http://www.navstasd.navy.mil/ .

17. Contract Report. 1995. *Underwater Facilities Inspections and Assessments at Naval Station San Diego, California.* NFESC EAST COAST DET. Report No. 55-95. June 1995.

18. Contract Report. 1995. *Underwater Facilities Inspections and Assessments at Naval Station San Diego, California Volume 2 – Appendices.* NFESC EAST COAST DET. CR-6220-OCN. September 2001.

19. https://www.nsi.navfac.navy.mil .

20. American Association of State Highway and Transportation Officials (AASHTO). 2002. *Standard Practice for Evaluation of Coating Systems with Zinc-Rich Primers.* AASHTO Designation: R 31-02. 2002.

21. Premier Coating Systems, Inc., Jacksonville Florida, (904) 824 – 1799.

22. Kevin J. Kovaleski. 2003. *Demonstration/Validation of a Zero-VOC Waterborne Polyurethane Topcoat.* ESTCP Cost and Performance Report. PP-9802. January 2003.

23. The Society for Protective Coatings (SSPC). 2001. *Estimating Costs in Protective Coatings Projects.* SSPC-TU 9. 2001.

24. Painting and Decorating Contractors of America (PDCA). 1994. *Professional Estimating Procedures for Painting Contractors.* 1994.

25. PDCA. 2001. *Estimating Guide: Volume 2, Rates and Tables*. 2001.

8. Points of Contact

1. **Daniel A. Zarate.** Naval Facilities Engineering Service Center/Code OP 63, 1100 23RD Ave., Port Hueneme, CA 93043-4370; (805) 982 – 1057, FAX (805) 982 – 1074.
2. **JASON BELL.** PolySpec, L.P., 6614 Gant Road, Houston, Texas 77066, (281) 397 – 0033, FAX (281) 397 – 6512.
3. **ALEX VAINER.** Polymeright Inc., 4404 – C Enterprise Place, Fremont, CA 94538; (510) 252 – 9090, FAX (510) 252 – 9206.
4. **SUSAN DROZDZ.** U.S. Army ERDC Paint Technology Center, P.O. Box 9005, Champaign, IL 61826-9005; (217) 373-6767, FAX (217) 373 – 6732.
5. **Michael Zapata.** HQ AFCESA/CESM, 139 Barnes Drive Suite 1, Tyndall AFB, FL 32403; (850) 283 – 6215, FAX (850) 283 – 6219.
6. **BOB WELCH.** Master Painters Institute, 4090 Graveley St., Burnaby, BC Canada V5C 3T6; (888) 674 – 8937, FAX (888) 211 – 8708.

Appendix A

"References to Methods"

ASTM STANDARDS

A 36/ A 36M	Specification for Carbon Structural Steel
B 117	Practice for Operating Salt Spray (Fog) Apparatus
D 476	Classification for Dry Pigmentary Titanium Dioxide Pigments
D 512	Test Methods for Chloride Ion in Water
D 520	Specification for Zinc Dust Pigment
D 521	Test Methods for Chemical Analysis of Zinc Dust (Metallic Zinc Powder)
D 523	Test Method for Specular Gloss
D 562	Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using the Stormer -Type Viscometer
D 610	Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces
D 714	Test Method for Evaluating Degree of Blistering of Paints
D 1186	Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base
D 1475	Test Method for Density of Liquid Coatings, Inks, and Related Products
D 1640	Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature
D 1652	Test Method for Epoxy Content of Epoxy Resins
D 1654	Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
D 2073	Test Methods for Total, Primary, Secondary, and Tertiary Amine

	Values of Fatty Amines, Amidoamines, and Diamines by Referee Potentiometric Method
D 2196	Test Method for Rheological Properties of Non -Newtonian Materials by Rotational (Brookfield -Type) Viscometer
D 2240	Test Method for Rubber Property—Durometer Hardness
D 2244	Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates
D 2369	Test Methods for Volatile Content of Coatings
D 2371	Test Method for Pigment Content of Solvent-Reducible Paints
D 2697	Test Method for Volume Nonvolatile Matter in Clear or Pigmented Coatings
D 2698	Test Method for the Determination of the Pigment Content of Solvent-Reducible Paints by High -Speed Centrifuging
D 3335	Test Method for Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
D 3718	Test Method for Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy
D 3960	Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
D 4060	Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
D 4285	Test Method for Indicating Oil or Water in Compressed Air
D 4400	Test Methods for Sag Resistance of Paints Using a Multinotch Applicator
D 4417	Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
D 4541	Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

D 4940	Test Method for Conductimetric Analysis of Water-Soluble Ionic Contamination of Blasting Abrasives
D 5894	Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal
D 6580	Standard Test Method for the Determination of Metallic Zinc Content in Both Zinc Dust Pigment and in Cured Films of Zinc Dust Pigment and in Cured Films of Zinc -Rich Coatings
E 11	Specification for Wire-Cloth and Sieves for Testing Purposes
E 1349	Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry
G 92	Practice for Characterization of Atmospheric Test Sites
G 140	Standard Method for Determining Atmospheric Chloride Deposition Rate by Wet Candle Method

FEDERAL STANDARDS

Fed Std. No. 40	CFR 51.100(s) Volatile Organic Compound Definition
Fed Std. No. 40	CFR 59.406(a) Volatile Organic Compound Compliance Provision
Fed Std. No. 40	CFR Part 59, Subpart D, Section 59.400 Through 59.413 National Volatile Organic Compound Emission Standards for Architectural Coatings
Fed Std. No. 40	CFR 261.24, Table 1 Maximum Concentration of Contaminants for the Toxicity Characteristic
Fed Std. No. 595	Colors Used in Government Procurement
EPA-SW846, Method 1311	Toxicity Characteristic Leaching Procedure (TCLP)

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

AB-3	Abrasive Specification Number 3, Newly Manufactured or Re-Manufactured Steel Abrasive
Guide 9	Guide for Atmospheric Testing of Coatings in the Field
PA 2	Measurement of Dry Paint Thickness with Magnetic Gages

Paint 20	Zinc-Rich Primers
SP 5	White Metal Blast Cleaning
SP 6	Commercial Blast Cleaning
SP 10	Near-White Blast Cleaning

Appendix B

“Data Quality Assurance/Quality Control Plan”

B.1 Quality Assurance for Laboratory Testing

Laboratory testing of the SZC under the American Association of State Highway & Transportation Officials (AASTO) National Transportation Production Evaluation Program (NTPEP) will be performed by the exclusive certified AASTO-Select Test Facilities, KTA-Tator, Inc. of Pittsburgh, PA.

B.2 Quality Assurance for SZC Coating Contractor

Only the Society for Protective Coatings (SSPC) QP-1 “Standard Procedure for Evaluating Painting Contractors (Field Application to Complex Industrial Structures)” certified coating contractors (or an experienced equal) will be permitted to submit a demonstration bid for this full-scale demonstration. Currently, only five coating contractors hold QP-1 certifications within the state of California.

B.3 Quality Assurance for Field Tests and Inspection

In addition to the guidance provided in UFGS 09 97 13.26 COATING OF STEEL WATERFRONT STRUCTURES, UFGS-09 97 13.27 “EXTERIOR COATING OF STEEL STRUCTURES,” Section 3.8 “FIELD TESTS AND INSPECTION,” subparts 3.8.1, 3.8.2, 3.8.2.1, 3.8.2.2, 3.8.2.3, and 3.8.2.4, entitled Coating Inspector, Field Inspector, Inspection Requirements, Daily Inspection Reports, Inspection Logbook, and Inspection Equipment, respectively, will be incorporated into the full-scale field demonstration contract.

B.4 Quality Control Plan

Under the heading below of “Quality Control Plan,” the first five pages of UFGS – 01450N “Construction Quality Control” (currently UFGS 01 45 00.00 20) are presented and will be slightly modified for use as a part of the full-scale field demonstration Quality Control Plan.

“Quality Control Plan”

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**************************************************************************
USACE / NAVFAC / AFCESA                     UFGS-01450N (April 2003)
                                            -------------------------------
Preparing Activity:  <PRA>NAVFAC</PRA>               Superseding
                                            UFGS-01450N (Febuary 2001)

                  UNIFIED FACILITIES GUIDE SPECIFICATIONS

          Revised throughout - changes not indicated by CHG tags
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SECTION TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS

01450N

[DESIGN AND]CONSTRUCTION QUALITY CONTROL

04/03

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCESA   UFGS-01450N (April 2003)

Preparing Activity: <PRA>NAVFAC</PRA>   Superseding
                                           UFGS-01450N (Febuary 2001)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

Revised throughout - changes not indicated by CHG tags
****

01450N

[DESIGN AND]CONSTRUCTION QUALITY CONTROL
04/03

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NOTE: This guide specification covers the preparation and use of Design-Build Quality Control and Design-Bid-Build Quality Control and as such must be edited for the acquisition method used. This guide specification covers the requirement for Quality Control (QC) for projects $100,000 and greater. It may be also used for smaller, complex projects at the discretion of the Government. This section requires specific editing of the QC requirements. Consult the EFD/EFA/OICC Construction Quality Management (CQM) Staff on appropriate guide specification to use. This section, as edited, shall be reviewed and approved by the CQM Staff prior to the 100 percent design submission.

This guide specification includes tailoring options for EFD/EFA,NW regional requirements. Selection or deselection of a tailoring option will include or exclude that option in the section. Editing of the resulting section to fit the project is still required.

Comments and suggestion on this specification are welcome and should be directed to the technical proponent of the specification. A listing of the technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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NOTE: INSTRUCTIONS TO VIEW/PRINT GRAPHICS

FROM CCB DISKS OR WEBSITE:

1. Put in Disk A and go to CCB Program, or go to www.ccb.org and sign in.
2. Choose Library.
3. Choose Specifications.
4. Choose NAVFAC Guide Specifications (English) or (Metric) graphics.
5. Open the file you need.

FROM ENGINEERING INNOVATION AND CRITERIA WEB PAGE: http://criteria.navfac.navy.mil

1. Choose "Unified Facilities Guide Specifications" link from the left.

2. Choose link for "GRAPHICS".

3. Scroll to Section graphic, English or Metric as needed, pdf file.

4. Limited graphics are available in DWG format. Request availablility from cgs@efdlant.navfac.navy.mil

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NOTE: Two options for the QC Manager duties have been incorporated into this guide specification. The first option allows the QC Manager to perform production related duties and the second option does not. Both options can include the use of QC specialists responsible for performing QC for specific areas of work and for a specified frequency. Specify QC specialists for those areas of work that are of sufficient complexity or size to justify the expense.

Determine whether a full time QC Manager is justified or whether it would be more cost effective to designate the project superintendent as the QC Manager, i.e. to act in a dual role. Consider:

1. Design and complexity of project;

2. Location of project;

3. Cost and type of Contract;

4. Characteristics of area construction labor market;

5. Amount and type of off-site fabrication.

6. Duration of project.

When requiring the use of a Registered Professional Engineer/Architect or a graduate Engineer/Architect for the QC Manager or QC specialist(s), keep in mind the additional cost. The over-specifying of expertise for QC personnel should be avoided.

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 880	(1995) Criteria for Use in Evaluation of Testing Laboratories and Organizations for Examination and Inspection of Steel, Stainless Steel, and Related Alloys
ASTM C 1077	(2002) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM D 3666	(2002) Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 3740	(2001) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM E 329	(2002) Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
ASTM E 543	(2002) Agencies Performing Nondestructive Testing

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(1996) Safety and Health Requirements Manual

Appendix C

"First Year Coating Survey Report"